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Nonlinear Source Function Development

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LONG TERM GOALS

The major source function, nonlinear wave-wave interactions (Snl), in the operational wave model (WAM) are calculated by the discrete interaction approximation (DIA). They are inaccurate, especially in shallow water. Our long term goal is to develop an accurate and efficient Snl and thereby improve the WAM fundamentally.

OBJECTIVE

The nonlinear source function (Snl) is highly nonlinearly distributed in frequency and direction; however, DIA is based on the piecewise assumption, which is incorrect. The exact-solution (5-dimensional integrations) by Hasselman and Hasselman (1981) is very time consuming and not practical. Resio and Tracy integrated Snl along the resonant orbits and reduced the 5-dimensional integrations to 3 dimensional integrations. Based on the fact that the Snl is highly nonlinearly distributed, we reduced 3-dimentional integrations (Resio and Tracy) to quasi-line integrations to minimize computational time.

APPROACH

The most exciting developments this last year have resulted from work related to improving techniques for evaluating the non-linear source function Snl, which, eventually, will be useful in operational wave models. In particular, during this year, a number of algorithms were compared, competitively, and the Reduced Integration Approximation (RIA) method was found to be the most reliable and fastest procedure for evaluating Snl of the various techniques considered. I am forwarding a paper that describes why this method is faster than had been previously believed (Lin and Perrie, "Wave-wave interactions in finite depth water, J. Geophys. Res., 104, 11193-11213) appeared in the May issue of JGR, which documents the efficiency and accuracy of the method. As a consequence of this paper, and various presentations I presented during the year (at Woods Hole Oceanography Institute, the Netherlands, the Bedford Institute of Oceanography of Canada, the Naval Research Laboratory, and David Taylor Model Basin), the model has been receiving considerable attention; (I have been invited to present talks at a number of additional places as well). Because the underlying science and mathematics is well understood, the associated model does not make approximations that some of the more empirically-based techniques make (and does not suffer from the "black box", hit or miss characteristics of some of these methods). But as in all existing "Exact Solution" models, there are a couple of limitations:

(1) If the initial spectrum is not a well-known spectrum, one needs to artificial add a tail to the initial spectrum based on the equilibrium energy spectrum theory;

(2) RIA is the fastest accurate model, but it is still too slow in comparison with the DIA and DIA2 methods.

But DIA and DIA2 are based on an inaccurate (piece-wide assumption) theory, which is opposite from true (the coefficients of Snl are highly nonlinear distributed). Therefore, they are can not be improved.

My colleagues and I are working on the Pseudo-spectrum method. This method overcomes all of the problems, which were mentioned above. It allows an arbitrary initial spectrum, and its CPU time scales as lnN, instead of the slower RIA method CPU time, which scales as approximately N, and the CPU time for the R-T(Resio and Tracy) method which scales as N^3, and the comparable H-H(Hasselmann and Hasselmann) CPU time, which scales as N^5, where N is truncation Number.

We still will have to solve some additional technical problems.